Biomass assessment for power generation in Tawang block, Tawang district, Arunachal Pradesh

Prepared for
Arunachal Pradesh Energy Development Agency
Itanagar, Arunachal Pradesh

TERI Project Report No. 2000 NE 61

A suggested format for citing this report is as follows.

T E R I. 2001
Biomass assessment for power generation in Tawang block,
Tawang district, Arunachal Pradesh
Guwahati, Assam: Tata Energy Research Institute.
[T E R I Project Report No 2000 NE 61]

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Taluka at a glance

Location	Situated in the central part of Tawang district, Arunachal Pradesh (27° 22' and 27° 45'E longitudes and latitudes 90°45' and 92° 15' N)	
Topography and climate	The topography of the block is mostly mountainous The main river of the district 'Tawang-Chu' is flowing through the block .The altitude of the block HQ Tawang is 3 025 mtr. The climate during winter ranges from moderately cool to severe, and summers warm and rainy The climate of the district is moderate during summer is moderate and extreme cold during the winter. The average annual temperature varies between –6.0°C and 27 0°C. The average annual precipitation in a year is about 2 413.42 mm	
Demography	Number of villages	96 nos
	Number of households	3 006 nos.
	Population(1991 Census)	13 060 (Male 7 408; Female 5 652)
	Scheduled Castes Scheduled Tribe	33 (Male.22 , Female.11) 9 126 (Male.4 600 , Female:4 526)
	Literacy rate	31 23% (Male: 40 94%; Female: 18 50%)
Infrastructure facilities	Total road length 56 15 km. No of electrified villages: 86	
Land-use	Geographical area	22 190 ha
	Evergreen forests	9 099 ha
	Degraded and deciduous forest	5 385 ha
	Land under cultivation	1 169 ha
	Land under Barren/rocky snow cover	5 160 ha
	Other uses	2 071 ha
Agriculture	Major crop Paddy, wheat, maize & millets Minor crops Pulses, Oilseeds, potato, etc.	
Major livestock	Cattle, yak, dzo, mithun, pigs, poultry, horses, & sheep/goats Total livestock population 21 342 (Cattle· 4676, Yak 2361, Dzo: 1348 Sheep 11142, Mithun 68, Horses: 676, Pigs: 771 and poultry 300)	
Forests	Unclassed state forest	: 14 484 ha
	Social forestry	: 606 ha
Industry	Rice mill, wheat mill, agarbati and wood carving industry.	

Biomass generation	Woody biomass	13 070 36 tonne/year		
	Crop residue	2 599 84 tonne/year		
Biomass consumption	Woody biomass	17 232.25 tonne/year		
	Crop residue	· 2 599 84 tonne/year		
Biomass surplus/(deficit)	Woody biomass	.(4 161.89) tonne/year		
	Crop residue	: Nil		
Woody biomass available for power generation	· Nil			
Suggested biomass conversion technology	Biomass gasifier based system with 100% producer gas engine as the prime mover			
Potential power generation	30-60 kWh/day			
Potential installed capacity	5-10 kW(operating time: 6 hours daily)			
Plan of action	Off grid decentralised power generation based on biomass gasifier, capacities of 5 kW & 10 kW and 100 % producer gas engine is a feasible alternative for electrification of four identified villages			
Suggested locations	Gasifier system	Location (*one system in each location*)		
	5-10 kW	Brakar Gompa		
	5-10 kW	Tseratse		
	5-10 kW	Langteng		
	5-10 kW	Collengteng		
Investment	Gasifier system	Capital cost (Rs)	O&M / month (Rs)	Biomass cost Rs /tonne
	5 kW	90 000.00	7 680 00	1 000 00
	10 kW	1 80 000.00	10 110.00	1 000 00

Note: The above costs do not include transmission and distribution costs

Contents

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Acknowledgement

Our sincere gratitude to Mr A Perme, Director, APEDA, Mr N Tatung, Ex-Director, APEDA for awarding the study to TERI. We are also thankful to Mr M Bam and Ms A Linggi Project Officer, APEDA for their kind support and co-operation.

We also are thankful to T T Dirkhipa, AE, Department of Power, (Electrical Sub-division), Tawang, DSO, Directorate of Economic and Statistics, Tawang, Officials at the Food and Civil Supplies Dept , AK Biswas, DFO, Tawang and all other officials of the Govt of Arunachal Pradesh for their kind help and co-operation during the execution of the field study

We are grateful to Manjushree Charitable Society for the extensive field support during the limited period of field study We are also thankful to Mr Manna Dutta, Prakhen Deuri and Mr Kesang Wangda for extending help during the primary survey In course of our study we interacted with households in the villages surveyed and would like to thank them for their kind co-operation

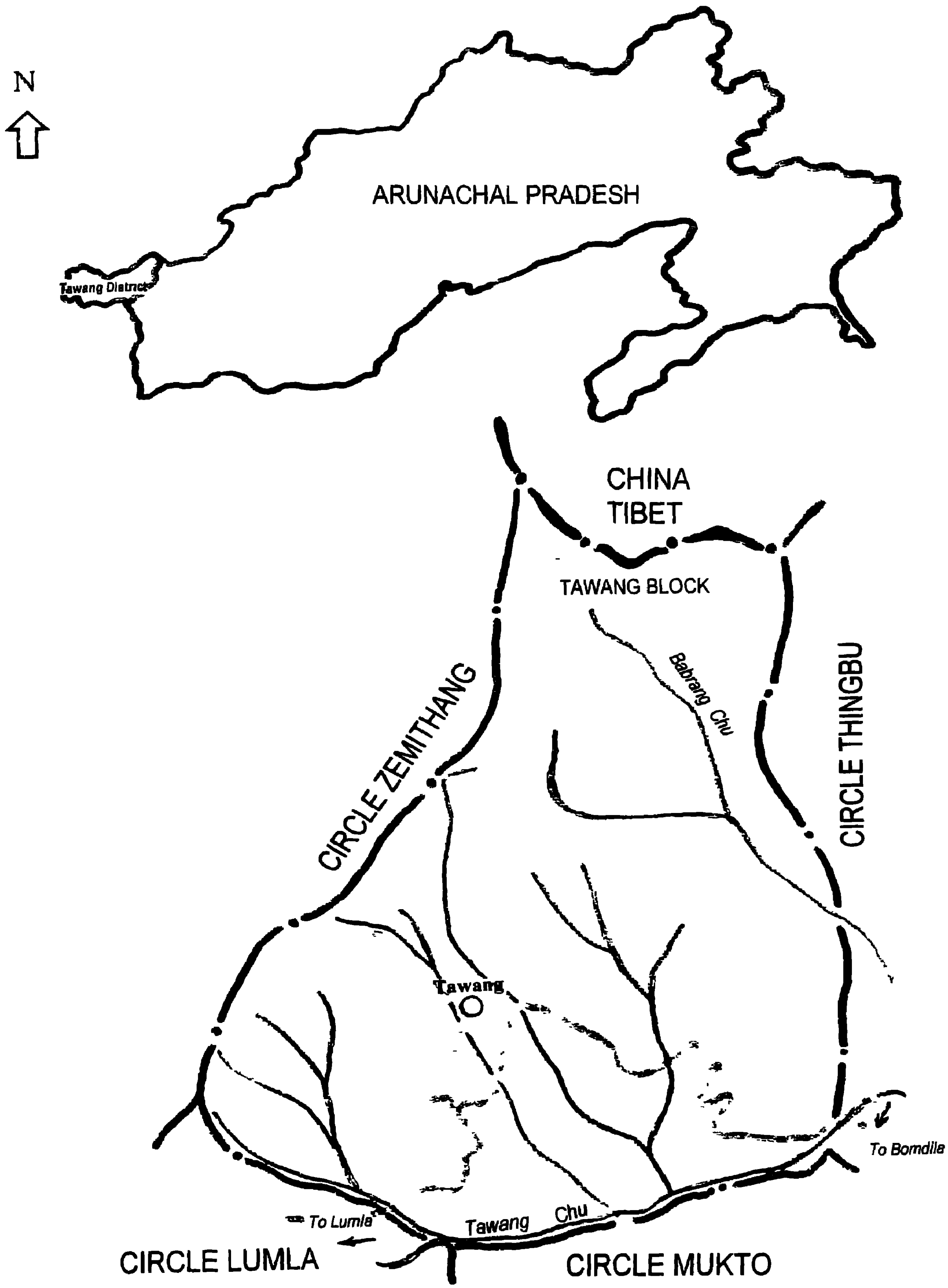
Our thanks to Dr R K Pachauri, Director-General, TERI and Dr Vibha Dhawan, Director, TERI, for their encouragement and support during the course of the study

Executive Summary

The biomass resources available in Tawang block are in the form of wood and agriculture residue Industrial power demand is insignificant in the absence of any large-scale industries except for small-scale units like rice/wheat mills

The consumption pattern of woody biomass in the block, with the consumption exceeding the sustainable yield, leaves no scope for surplus woody biomass The concentration of households in the unelectrified villages being limited and biomass for power generation being deficient in the block *hence centralized generation of power is economically not a feasible proposition* In the present scenario of power generation based on micro hydro and DG sets at Tawang, available power to mitigate the additional demand 2 50 MWh/month exist based on the present 15% evacuating capacity through grid extension But off grid **decentralized power generation based on biomass gasifier and 100 % producer gas engine is a feasible alternative** for electrification of identified villages The power generated could thus electrify the village Thus, the following options are recommended for dissemination of gasifiers for power generation at decentralized level

- Based on cost economics of grid extension and decentralized power generation based on biomass gasifier, economically feasible option can be taken into consideration for village level electrification
- Gasifier capacities of **5kW and 10kW** can be installed at the villages
- Potential for introduction of biomass based power generation through gasifier is possible at district headquarter, Tawang, where three diesel power generating unit of capacities 625 kVA, 500 kVA and 300 kVA are in operation However, suggestion for fuel wood supplement for 100 % biomass gasifier based decentralized power generation system has to be a centralized procurement mechanism



Notional map of Arunachal Pradesh and Tawang Block with circle headquarter

Chapter 1

Introduction and methodology

.1 Introduction

Biomass resources comprise organic matter derived directly or indirectly from forestry and agriculture or livestock activities. namely wood, crop residues, and animal wastes. Given the overwhelming dependence of India's rural population on traditional biomass resources for meeting its energy demand, the effective utilization of such resources requires focused planning efforts More so, because of the limited options in terms of fuel sources available in rural areas. Fuelwood, agricultural residues and animal dung contribute between 90-95% of the total fuel consumed in domestic sector, and fuelwood alone accounts for 65% (NCAER 1985).

It is estimated that more than 500 million tonnes of crop residues are generated every year in the country Conservative estimates indicate that with the present utilisation pattern of the crop residues and by using the surplus biomass material more than 16 000 MW of grid quality power can be generated for decentralised applications In addition, 3 500 MW of power can be produced if all the sugar mills switched over to co-generation technology According to estimates, India has a potential of generating 19 500 MW of power by processing biomass through cogeneration, combustion and gasification routes (MNES 2001)

.2 Objective of the study

The proposed study is being conducted under MNES's taluka level biomass assessment and power generation initiative. The overall objective is to assess the availability of biomass resources for gasifier based power generation in Tawang block of Tawang district, Arunachal Pradesh The key parameters studied are as follows.

1. Assessment of availability, production and utilization of biomass in Tawang block, Tawang district in Arunachal Pradesh through household/village/block level primary survey
2. Estimation of surplus biomass availability in the block, which could form the basis for planning for power generation.
3. Assessment of quantum of electricity to be generated from biomass gasification in the selected block and capacity of power plants to be installed.

.3 Methodology

The study is primarily designed to estimate the availability of likely surplus biomass for power generation in Tawang block, Tawang district, Arunachal Pradesh and the power

requirements of the block The focus is on woody biomass and crop residues Secondary data supplemented by primary survey of twenty villages in the study block are the basis of the estimations made. For the present study, secondary data have been reconciled with primary data collected for corroborating the total information requirements.

1.3.1 Secondary data collection

Detailed information was sought from the secondary sources. Data related to demographic, social, and economic parameters were collected to understand the land use pattern, resource management systems, productivity of biomass, etc. In addition, information was obtained for assessing the technical feasibility of biomass based power generation without putting unsustainable pressures on the biomass resource. Apart from the available literature, most of the data collected was based on personal interactions with relevant agencies (Agriculture Department, PWD, Forest Department, Veterinary Department, Power dept., Directorate of Industries, etc) as also with knowledgeable individuals and organizations Table 1.1 provides the details on the type and source of the data collected.

Table 1.1 Type and source of secondary data

Information	*Source*
District headquarters	
Census records and district profile	Statistics branch, Deputy Commissioner's Office, Tawang and Director of Census Operations
Land use, Cropping pattern, Irrigation schemes	A Resource Atlas of Arunachal Pradesh
Kerosene supply	District Supply Office
Industrial profile	Directorate of Industries
Power supply and consumption	Dept of Power
Forest area, sustainable yield of forests	Divisional Forest Office (DFO) A resource Atlas of Arunachal Pradesh Forest Survey of India
Block level	
Households, Population, infrastructure	Director of Census Operations, Circle Office, Block Development Office,
Land use, grain production, irrigation systems, agriculture markets, water supply facilities	District Agriculture Officer, Circle officer
Industries	District Industries & Commerce Centre
Power supply and consumption, Kerosene supply	Dept of Power, District Supply Office

1.3.2 Selection of villages

For the proposed study twenty villages out of the total ninety-six villages in Tawang block were taken into account The remaining seventy-six villages were not considered because of the allotted time frame and logistical constraints The Directorate of

Economics & Statistics, Itanagar, provided the list of the villages and its distribution in the block

1.3.3 Primary data collection

Primary data were collected from the surveyed villages to ascertain the resources available and their utilisation patterns, and the prevalent socio-economic practices An assessment was made of the electricity consumption and likely demand, crop residue availability, fuelwood use and infrastructural needs In the surveyed villages, survey schedules were administered at the household level as well as village level. The details on the type and source of information collected are presented in table 1 2.

Table 1.2 Type and sources of primary information

Information	*Source*
Population, industries, land use, agriculture crop production, development of service sector, etc	Village headman, households, commercial establishments, local shopkeepers
Biomass collection and consumption, agriculture development, market prices, etc	Households, village headman, commercial establishments
Power consumption pattern, biomass processed or consumed, electricity consumption, kerosene/diesel consumption, power cuts, operational periods, etc	Commercial establishments (hotels, Circuit house restaurants, Guest House), households, power dept , District Supply Department

1.4 Data analysis

To assess the biomass supply from the various sources and its consumption by different end-users and the surplus available, computations were based on secondary and primary information. Probable sites for power generation are identified and constraints associated with the proposed power generation reviewed. The following methodology was used to arrive at the estimations

1.4.1 Agriculture residues

This is a factor of agricultural area, crop type, the grain yield and grain to residue ratio.
Residue production (t)= crop production (t) × residue production ratio

1.4 2 Woody biomass

The major sources of woody biomass are the forest division found in the study block and adjoining block. In additions, plantations established by Social Forestry Division, Forest Department supplies considerable woody biomass

Total growing stock = Total area under forests (incl. plantations) × plant productivity[1] (cu m/ha)
Annual Sustainable Yield (t) = 1% of total growing stock × density of wood[2]. This is also the maximum available sustainable yield on annual basis in tonnes. (considering a rotation period of 100 years)

1.4.3 Assessment of biomass consumption

For the domestic sector, use of fuelwood for different end-uses including cooking and space heating at the household level was assessed to obtain the annual household wood consumption at the block level. Similarly, for crop residues, the quantum used for end-uses of fuel, fodder and manure is discounted from the total residue production to estimate the surplus In addition, fuelwood and crop residue harvesting and disposal practices, and transportation arrangements, and prevalent market prices of biomass were also studied at the village level The commercial sector in the block comprises mainly of shops and restaurants, wherein firewood is utilised for cooking and space heating The industrial sector consisting of rice mills and wheat mills/watermill generally use electricity and mechanical hydropower applications.

Annual domestic fuelwood consumption = number of households × daily average fuelwood consumption (kg/day) × 365 days

Annual commercial fuelwood consumption = number of establishments × daily average commercial fuelwood consumption (kg/day) × 365 days

1.4.4 Assessment of kerosene consumption

Kerosene consumption is calculated on the basis of primary survey at household level.
Annual kerosene consumption at block level = number of households × monthly average household consumption (litre/month) × 12 months

1.4.5 Electricity consumption in domestic sector

Electricity consumption by domestic sector was calculated on basis of primary surveys as well as secondary data collected from Dept. of Power, Tawang Sub-Division

Total annual electricity consumption (kWh/year) = monthly average household consumption (kWh/month) × Total households × 12 months

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1 Forest Survey of India 1996 Inventory of Forest Resources of India

2 Forest Survey of India 1996 Fuelwood Timber & Fodder from Forests of India

1 4.6 Electricity consumption in commercial/industrial sector

Power consumption by commercial sectors is calculated on the basis of secondary data provided by Dept of Power Govt of Arunachal Pradesh

Total annual electricity consumption (kWh/year) = monthly average consumption by commercial/industry sector (kWh/month) × Total numbers × 12 months

1 5 Power generation potential

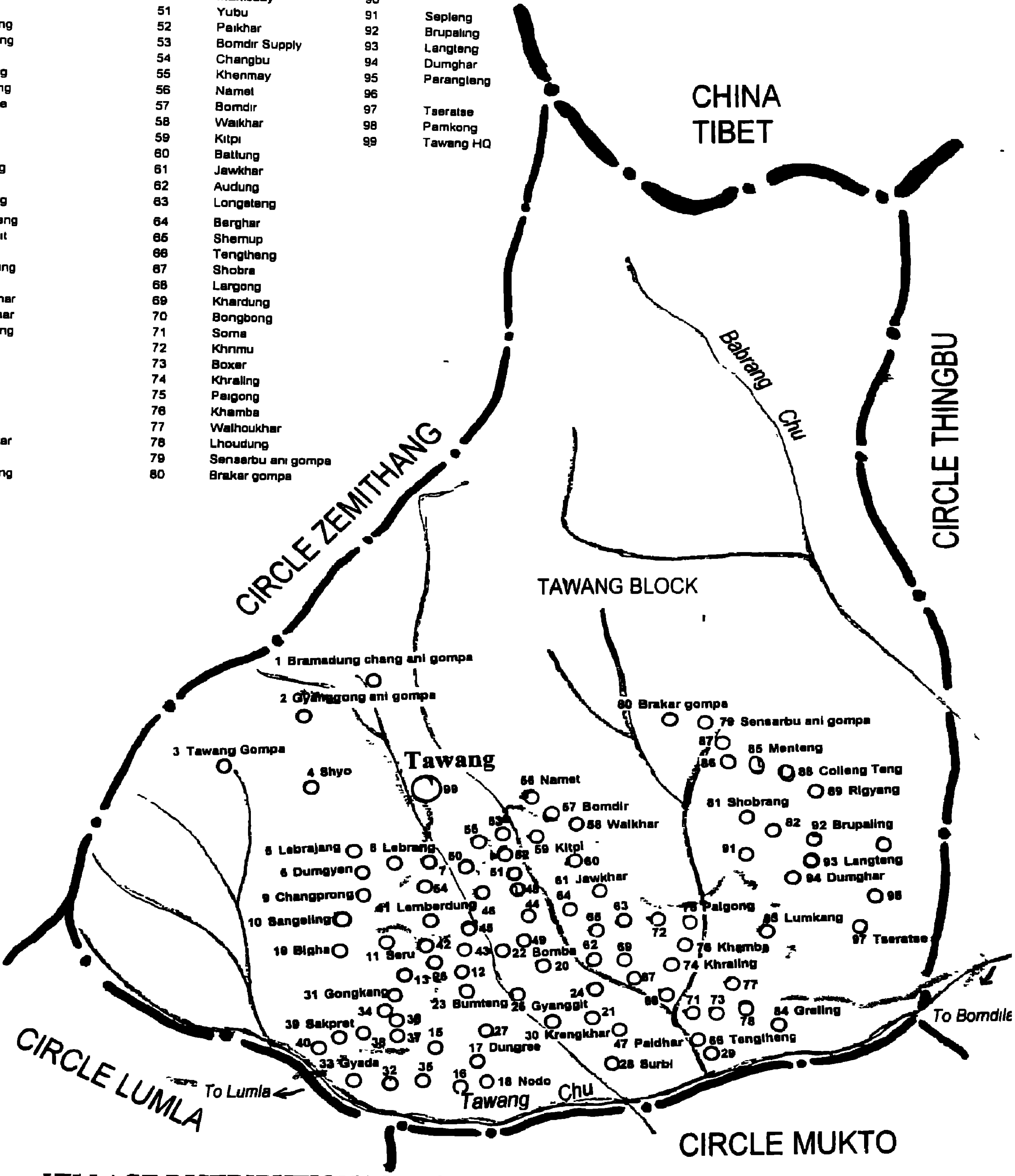
Biomass based power generation is dependent on the type of biomass conversion technology to be adopted and feedstock to be used Biomass conversion technologies are under refinement and the input-output ratios are being standardised for various feedstock, especially for dual fuel mode based gasifier units For the proposed study, the potential for power generation is calculated for gasifiers operating on dual fuel mode technology

In a gasifier based dual fuel mode of operation, the specific fuel consumption per unit generation is as follows

Wood: 1.0 kg/kWh and Diesel: 100 ml/kWh (Jain 1994)

Crop residue: 1.5 kg/kWh (Ankur 1998)

Code No	Village	Code No	Village	Code No	Village
1	Bramadung chang ani gompa	41	Lemberdung	81	Shobrang
2	Gyanggong ani gompa	42	Oungkhar	82	Regyang
3	Tawang Gompa	43	Gyangkhar	83	Lumkang
4	Shyo	44	Sikhar Teng	84	Greling
5	Lebrajang	45	Khartoot	85	Menteng
6	Dumgyen	46	Gyangkhardung	86	Gemrateng
7	Urgeling	47	Paidhar	87	Lunykemde
8	Lebrang	48	Damakang	88	Collengteng
9	Changprong	49	Shakpteling	89	Rigyang
10	Sangeling	50	Mamsaay	90	
11	Seru	51	Yubu	91	Sepleng
12	Blamleng	52	Paikhar	92	Brupaling
13	Kangteng	53	Bomdir Supply	93	Langteng
14		54	Changbu	94	Dumghar
15	Shyajing	55	Khenmay	95	Parangleng
16	Gormang	56	Namet	96	
17	Dungree	57	Bomdir	97	Tseratse
18	Nodo	58	Waikhar	98	Pamkong
19	Bigha	59	Kitpi	99	Tawang HQ
20	Kitkhar	60	Batlung		
21	Maidung	61	Jawkhar		
22	Bomba	62	Audung		
23	Bumleng	63	Longateng		
24	Changleng	64	Berghar		
25	Gyanggit	65	Shemup		
26	Tele	66	Tengtheng		
27	Pempaling	67	Shobra		
28	Surbi	68	Largong		
29	Grengkhar	69	Khardung		
30	Krengkhar	70	Bongbong		
31	Gongkang	71	Soma		
32	Saikhar	72	Khrimu		
33	Gyada	73	Boxer		
34	Sabur	74	Khraling		
35	Yusum	75	Paigong		
36	Kudung	76	Khamba		
37	Sohung	77	Walhoukhar		
38	Pamaghar	78	Lhoudung		
39	Sakpret	79	Sensarbu ani gompa		
40	Thongleng	80	Brakar gompa		



VILLAGE DISTRIBUTION MAP OF TAWANG BLOCK

Chapter 2

Profile of taluka

2.1 Tawang district

Tawang district lies between 27^0 22′ E to 27^0 45′ E longitudes and 90^0 45′ N to 92^0 15′ N latitudes The district shares its boundary with Tibet in the north, Bhutan in the south and west and Sela Range separated from West Kameng district in the east. The total geographical area of the district is approximately 2 085-sq. km and is divided into three administrative sub-divisions· Tawang, Lumla and Jang Tawang has only one circle viz., Tawang sadar circle, Lumla sub division comprises of Lumla and Zemithang circle and Mukto and Thingbu circles come under Jang subdivision The total number of villages in the district is 163 nos and population is only 28 287 persons (District Statistical Hand book 2000)

2.1.1 Topography

About two third of the entire district consists of high mountainous region. The highest mountain peak in the district is known as 'GAURICHEN' which is about 22 500 feet MSL There are two main rivers namely Tawang-Chu and Nyamjang-Chu Most of the villages are concentrated in the basins of the two river valleys. In the Tawang district there is a mountain range known as Sela-Range consisting of mountainous in the form of big line from Tibet in the north, Bhutan in the south & west, thus forming a tough terrain to pass through Its altitude varies from 14 000 to 15 000 feet. (District Statistical Hand book 2000)

2.1.2 Climate

The climate of the district is moderate during summer and extreme cold during the winter The average annual temperature varies between –6 0°C and 27 0°C. Rains are experienced from March to October and the heaviest rainfall occurs during June to August From November to February there is negligible or almost no rainfall. The average annual precipitation in a year is about 2 413 42 mm (District Statistical Handbook 2000)

2.2 Tawang block

Tawang block occupies the central part of the Tawang district The block is bounded by Tibet in the north, Mukto circle in the south. Thingbu circle in the East, Lumla and Zemithang circle in the west. The block falls under the administrative jurisdiction of the

Tawang sub-division. The block has twenty Gaon Panchayat (GP) consisting of 96 villages (Block level Statistics of Tawang district, 1999)

2.2.1 Demography and socio-cultural profile

The population of Tawang block is mainly rural, accounting for 46.16% (13 060 persons) of the district's total population (as per1991 Census). The total number of households in Tawang is 3 006. The literacy level in the block is 31 23% with very low (18.50%) female literacy (1991 Census). Majority of the population (69.87%) in the district comprises of scheduled tribe. (District Census Handbook, 1991) The inhabitants of the block consist mostly of Monpa tribe belonging to the Mongoloid races.

2.2.2 Infrastructure facilities

The infrastructure facilities in the block are moderately developed The total road length under the PWD in the block is only 56 15 km Eighty six villages of the total 96 villages are electrified The common modes of transportation here are jeep, pony, and horses Educational facilities available in the block ranges from Pre-primary to higher secondary schools The local population lacks access to primary health centres and dispensaries as only one district hospital, four health sub centres, one dispensary and three homeopathy centre exist in the block (Table 2.1).

Table 2.1 Infrastructure facilities in Tawang

Facility	Number
Schools (Pre- Primary, Primary, Middle and Secondary)	41
Higher Secondary School	1
Allopaty medical institutions	6
Aurvedic/homeopathy institutions	3
Veterinary dispensary & aid centre	6
Post office (incl branch post office)	4
Telephone exchange	2
Co-operative society	3
Bank	2

Source *District Statistical Handbook 2000, Block level Statistics of Tawang, 1999*

There is only one sub-post and three branch post offices in the block There are also two telephone exchanges at the block Out of the total 96 villages, only five villages are having water supply facilities provided by the state PHE dept The rest of the villages get their water from nearby streams.

2.2.3 Land use

A variety of land cover with complex areal association is found in the Tawang Himalayas because of the complex micro relief features The mountain peaks and high hills of the Greater Himalayas are covered with snow Because of glaciation, the landscape of these areas is characterised by rocky and barren lands. A longitudinal belt of degraded forests are marked on the high hill ridges and escarpments of Tawang – Kameng borderlands The moderate slopes of the Tawang Chu and Nyamjong Chu exhibit temperate evergreen forests The river valley flats and inter- piedmont valleys have small patches of settled cultivation, unlike in other districts of the state where *jhum* cultivation is predominant

Table 2.2 Land use pattern in Tawang block

Land type	Area (in ha)
Geographical area	22 190
Evergreen forests	9 099
Degraded and deciduous forest	5 385
Land under cultivation (Rabi, Kharif etc)	1 169
Land under Barren/rocky snow cover	5 160
Other uses (lakes Streams, built up areas)	2 071

***Source** A Resource Atlas of Arunachal Pradesh 1999, Block Level Statistics of Tawang District 1999*

2.2.4 Scenario of EB substations

Substations of various capacities namely 25 kVA, 63 kVA, 100 kVA, 500 kVA have been set up for distributing power in the block In addition, another eight substations have been provided to various state and central govt departments The Tawang Electrical Sub-division of the Power dept is responsible for the operation and maintenance of these substations (Table2 3)

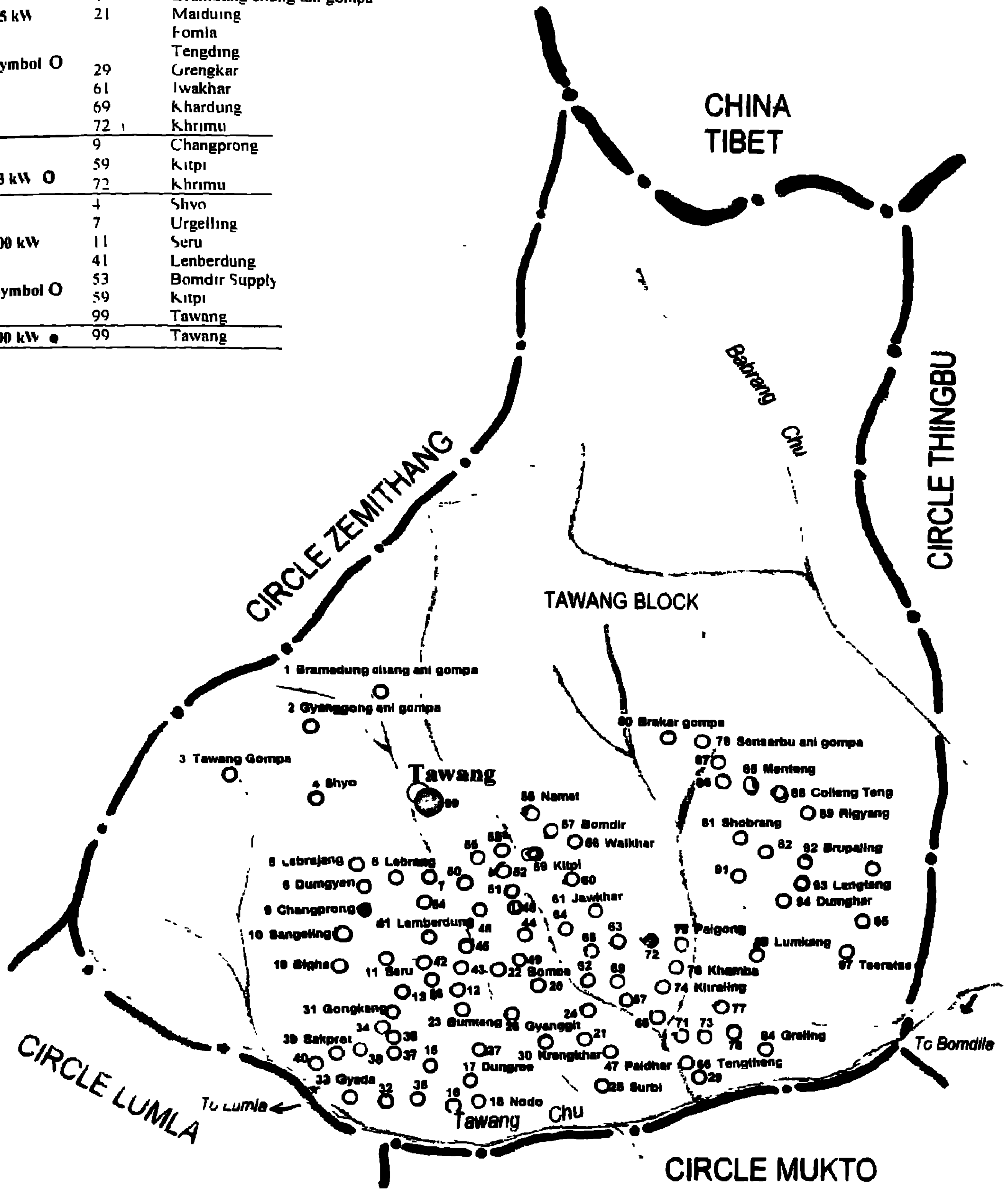
Table 2.3 Distribution of EB substations in Tawang

Capacity	**25 kVA**	**63 kVA**	**100 kVA**	**500 kVA**
Villages where EB substations are located	Fomla Tengding Khrimu Maidung Jawkhar Khardung Grengkhar Bramadunhg chung ani gompa, Gyanggong ani gompa	Khrimu Kitpi Chamgprong	Lemberdung Bomdir supply Kitpi Shyo Tawang Seru, Gormang, Nodo, Tele, Dungree	Tawang

***Source** Department of Power, Tawang 2001*

EB Substations distribution:

Substation Capacity	Village Code	Name of Village
	1	Bramdung chung ani gompa
25 kW	21	Maiduing
		Fomla
		Tengding
Symbol O	29	Grengkar
	61	Iwakhar
	69	Khardung
	72	Khrimu
	9	Changprong
63 kW O	59	Kitpi
	72	Khrimu
	4	Shyo
	7	Urgelling
100 kW	11	Seru
	41	Lenberdung
Symbol O	53	Bomdir Supply
	59	Kitpi
	99	Tawang
500 kW ●	99	Tawang



Distribution of EB substations in Tawang Block

Chapter 3

Baseline data

3 1 Annual energy consumption

Table 3.1 Annual Energy consumption

Type of fuel	Total consumption
Firewood (t/y)	17 232 34
Kerosene (l/y)	2 00 120
LPG (C/m)	1 483
Electricity (kWh/y)	1 276 001 36

Source Primary survey 2001

3.3 Domestic electricity consumption

Table 3.2 Domestic electricity consumption

Sl No	Village	No of Households ***1991 Census***	Households electrified ***Primary survey 2001***	Annual electricity consumption kWh/month
1	Bramadung chang ani gompa	17	14	350
2	Gyanggong ani gompa	26	16	400
3	Tawang Gompa	66	72	4380
4	Shyo	150	163	2962
5	Lebrajang	13		
6	Dumgyen	24	18	455
7	Urgelling	32	23	460
8	Lebrang	14	29*	769
9	Changprong	39	39	1165
10	Sangeling	3		
11	Seru	101		
12	Blamleng	4		
13	Kangteng	27	UE	
14				
15	Shyajing	12		
16	Gormang	10		
17	Dungree	5		
18	Nodo	5		
19	Bigha	27	6	175
20	Kitkhar	9	7	245
21	Maidung	7	9	270
22.	Bomba	32	20	700
23	Bumteng	10	5	175
24	Changleng	3		
25	Gyanggit	7	6	201

26	Tele	15		
27	Pempaling	4		
28.	Surbi	42	23	690
29	Grengkhar	9		
30	Krengkhar	10	7	210
31	Gongkang	8		
32	Saikhar	16		
33	Gyada	13		
34	Sabur	10		
35	Yusum	20		
36	Kudung	9		
37	Sohung	9		
38	Pamaghar	51		
39	Sakpret	25		
40	Thongleng	106		
41.	Lemberdung	77	67	3015
42	Oungkhar	4	4	120
43	Gyangkhar	23	20	700
44	Sikhar Teng	7	UE	
45	Khartoot	11	9	270
46	Gyangkhardung	4		
47	Paidhar	14		
48	Damakang	12	6	207
49	Shakpteling	3		
50	Mamsaay	15	13	NA
51	Yubu	9	3	89
52	Paikhar	24	17	481
53	Bomdir Supply	133	37	1806
54	Changbu	32		
55	Khenmay	6		
56	Namet	38	35	2172
57	Bomdir	41	20	1282
58	Waikhar	26	19	715
59	Kitpi	49	42	1122
60	Battung	10	11	316
61	Jawkhar	15	5	147
62	Audung	28	27	754
63	Longeteng	1		
64	Berghar	15	11	300
65	Shernup	21	16	509
66	Tengtheng	16	11	330
67	Shobra	6	UE	
68	Largong	17		
69	Khardung	38	28	780
70	Bongbong	10	UE	
71	Soma	12	2	60
72	Khrimu	116	90	3139
73	Boxer	13	11	295
74	Khraling	21	15	510

75	Paıgong	90		
76	Khamba	24		
77	Walhoukhar	13		
78	Lhoudung	55		
79	Sensarbu anı gompa	50		
80	Brakar gompa	1	UE	
81	Shobrang	15		
82	Regyang	21		
83	Lumkang	6		
84	Grelıng	19		
85	Menteng	3		
86	Gemreteng	5		
87	Lunykemdeng	3		
88.	Colleng Teng	4	UE	
89	Rıgyang	15		
90				
91	Sepleng	3		
92	Brupalıng	4		
93	Langteng	3	UE	
94	Dumghar	3		
95	Parangteng	1	UE	
96				
97	Tseratse	3	UE	
98	Pamkong	1	UE	
99	Tawang HQs	807	1613	70 426
	Total	**3 006**	**2 589**	**10 3152 / 117240***

Source Prımary survey 2001

* Fıgure represented for 86 vıllages

3.2 Village-wise energy consumption

Table 3.3 Vıllage-wıse annual energy consumptıon pattern

Sl No	Vıllage	No of HH	Total annual energy consumptıon		
			Fuel wood(t/y)	Kerosene* (l/y)	LPG(c/m)
1	Bramadung chang anı gompa	17	76 5*	1020	
2	Gyanggong anı gompa	26	121 68	1560	
3	Tawang Gompa	66	261.36	3960	30
4	Shyo	150	675*	9000	
5	Lebrajang	13	60 84	780	
6	Dumgyen	24	146 88	1440	17
7	Urgellıng	32	138 24	1920	19
8	Lebrang	14	70 56	840	10
9	Changprong	39	275.4	2400	45
10	Sangelıng	3	19 44	180	
11	Seru	101	399 96	6060	30
12	Blamleng	4	18*	240	
13	Kangteng	27	165 22	1620	15
14					

15	Shyajıng	12	99*	720	
16	Gormang	10	45*	600	
17	Dungree	5		300	
18	Nodo	5	174 96	300	8
19	Bıgha	27		1620	
20	Kıtkhar	9		540	
21	Maidung	7		420	
22	Bomba	32	373 5*	1920	
23	Bumteng	10		600	
24	Changleng	3		180	
25	Gyanggıt	7		420	
26	Tela	15	21 6	900	
27	Pempalıng	4		240	
28	Surbı	42		2520	
29	Grengkhar	9	382 5*	2700	
30	Krengkhar	10		600	
31	Gongkang	8		480	
32	Saıkhar	16	65 52	960	
33	Gyada	13	50 4	780	
34	Sabur	10	135 5*	600	
35	Yusum	20		1200	
36	Kudung	9	55 08	540	
37	Sohung	9	330 48	540	15
38	Pamaghar	51	108	3060	
39	Sakpret	25	477*	1500	
40	Thongleng	106	415 8	6360	10
41	Lemberdung	77	15 84	4620	
42	Oungkhar	4	140 76	240	
43	Gyangkhar	23	31 5*	1380	
44	Sıkhar Teng	7	71 28	420	
45	Khartoot	11	18	660	
46	Gyangkhardung	4	63	240	
47	Paldhar	14	77 76	840	
48	Damakang	12		720	
49	Shakptelıng	3		180	
50	Mamsaay	15		900	
51	Yubu	9		540	
52	Paıkhar	24	1170*	1440	
53	Bomdır Supply	133		7980	
54	Changbu	32		1920	
55	Khenmay	6		360	
56	Namet	38	191 88	2280	
57	Bomdır	41	117	2460	
58	Waikhar	26	211 68	1560	
59	Kitpı	49	3064 5*	2940	
60	Battung	10		600	
61	Jawkhar	15		900	
62	Audung	28		1680	
63	Longeteng	1		60	

64	Berghar	15		900	
65	Shernup	21		1260	
66	Tengtheng	16		960	
67	Shobra	6		360	
68	Largong	17		1020	
69	Khardung	38		2280	
70	Bongbong	10		600	
71	Soma	12		720	
72	Khrimu	116		6960	
73	Boxer	13		780	
74	Khraling	21		1260	
75	Paigong	90		5400	
76	Khamba	24		1440	
77	Walhoukhar	13		780	
78	Lhoudung	55		3300	
79	Sensarbu ani gompa	50		3000	
80	Brakar gompa	1		60	
81	Shobrang	15		900	
82	Regyang	21		1260	
83	Lumkang	6		360	
84	Greling	19		1140	
85	Menteng	3		180	
86	Gemreteng	5		300	
87	Lunykemdeng	3		180	
88	Colleng Teng	4		240	
89	Rigyang	15		900	
90					
91	Sepleng	3		180	
92	Brupaling	4		240	
93	Langteng	3		180	
94	Dumghar	3		180	
95	Parangteng	1		60	
96					
97	Tseratse	3		180	
98	Pamkong	1		60	
99	Tawang HQs	807	3195 72	48420	
	Total	**3 006**	**13 527.34**	**1 82 580**	**199**

Source Primary survey 2001

Note: *Annual fuel wood consumption for those villages which could not be surveyed has been clubbed and figures related to fire wood consumption has been projected based on consumption figures from the villages surveyed.*

3.4 Industry level energy consumption

Table 3.4 Industry level energy consumption

Type	No of units	Annual average energy consumption		Annual energy consumption	
		Diesel (lit/y)	Elect (kWh/y)	Diesel (lit/y)	Elect* (kWh/y)
Rice /wheat mills	6	-	268.56	-	1611 36
Agarbati Industry	1	-	-	-	-
Wood carving	2	-	-	-	-
Total	**9**	**nil**	268 56	**nil**	1611 36

Source Primary survey 2001

3.5 Energy consumption of commercial activities/public utilities, agricultural activities and other misc. activities

Table 3.5 Energy consumption of commercial activities

Type of consumers	Annual energy consumption			
	Fuelwood(t)	LPG (cyl)	Kerosene (lit)	Electricity (kWh)
Shops and Restaurants	105	1 260	14 660	6 048
Bakery	3 600	24	1920	518
Public utilities/Govt Institution	-	-	960	30 000
Total	**3705**	**1284**	**17 540**	**36 566**

Source Primary survey 2001



Procurement and chopping of firewood for cookstoves and bukhari.

Chapter 4

Biomass generation as per land area classification

4.1 Biomass from forests

Tawang block has two administrative circles and comprises a total of 20 *Gaon* Panchayats (GP). Most of the land area is under Unclassed State Forest (USF) consisting both evergreen and deciduous forests Off late the forest dept has also started the plantations under the social forestry scheme in the block. As no forest survey was undertaken for the block by the State Forest Dept., so the forest cover data was taken from the Resource Atlas of Arunachal Pradesh According to the Atlas, the Tawang block has about 65.27% of its total area under evergreen and deciduous forests. However, the Social forestry division of the Forest Department has established 606 ha of plantations consisting of Social forestry, Artificial Plantations, Apna Van etc (District Statistical Handbook 2000) in the block. For assessing the biomass generation from forests, the productivity and sustainable yield from only USF has been calculated, as this constitute the main fuelwood and timber supply sources The yield from social forestry has not been calculated, as the dept. generally permit only procurements of minor forest products for about four month in a year from such areas. In addition, some amount of biomass is also produced from the homestead, comprising mostly of fruit and fodder trees. But the amount of biomass from such areas is of negligible quantity The annual biomass production from the Unclassed State Forest is 13 07 036 16 tonne and the sustainable yield is 13 070.36 tonnes/year (Table 4 1).

Table 4.1 Biomass generation from forest

Type	Area (ha)	Productivity (m^3/ha)	Total growing stock (m^3/y)	Total growing stock (t/y)	Sustainable yield (t/y)
Unclassed State Forest	14 484	112 8 [1]	16 33 795 2	13 07 036 16	13 070 36
Social forestry	606	129 59 [2]	78 531 54	62 825 23	628 25

***Source** A Resource Atlas of Arunachal Pradesh 1999; District Statistical Handbook 2000*

3 Biomass from barren lands, cultivable waste land and others

The biomass available in cultivable wastes, fallow land, barren lands, etc. is usually grass and shrub. Such lands are scattered and are not restricted to any area in the block. Moreover, as Tawang falls under the temperate areas, most of the high altitude areas are

[1] Forestry in the Himalayan States of India, 1997

[2] Forest Survey of India 1996

under periodic snow cover for about four to five months in a year. Therefore the annual total yield from such lands is 7 836 tonnes and the sustainable yield is only 78.36 tonnes. (Table 4.2).

Table 4.2 Biomass generation from miscellaneous lands

Land type	Area (ha)	Biomass type	Productivity[2] (t/ha)	Total growing stock (t/y)	Sustainable yield (t/y)
Fallow land	93	Grass & shrubs	3.4	316.2	3 16
Cultivable waste land	87	Grass & shrubs	3.4	295.8	2 96
Barren/ snow cover land	5160	Shrubs	1.4	7224	72 24

***Source.** A Resource Atlas of Arunachal Pradesh 1999, Block Statistics of Tawang 1999*

4.4 Biomass from agriculture land

Wheat, paddy, maize and millet are the major agricultural crop of Tawang block and covers an area of 366 ha, 146 ha, 165 ha and 135 ha respectively. Other crops grown in the block include pulses, oilseeds, potato and seasonal vegetables. Based on the cultivation area under respective crops, only field crops such as paddy, wheat, maize millet, oilseeds and pulses are taken into account for calculation of residue generation. Though potato is also grown in an area of about 415 ha, but the biomass generated from potato has not been taken into account as the residue of potato would not be feasible for power generation. Moreover the quantity of Maize cob is limited and distributed within individual households therefore it would be feasible to collect at a central place and hence cannot be taken into account for calculation of biomass residue Therefore the total annual agricultural residue generated from major crop is 2117.84 ton (excluding residue generated from cob) and from minor crops is 482 ton (Tables 4.3 and 4.4).

Table 4.3 Residue generation of major crop (1999-2000)

Crop	Production (t/y)	Type of residue	Crop / Residue ratio[3]	Residue production (t/y)
Paddy	189 8	Straw & husk	Straw 1 76	Straw 334.04
			Husk 0 267	Husk 50 67
Maize	306	Stalk & cob	Stalk 2 00	Stalk 612
			Cob 0 273	Cob 83 53
Wheat	512 4	Stalk	1 75	Stalk 896 7
Millets	128 25	Stalk	1 75	Stalk 224 43

Source District Statistical Handbook, Tawang 2000

Table 4.4 Residue generation of minor crops (1999-2000)

Crop	Production (t/y)	Type of residue	Crop /Residue ratio[3]	Residue production (t/y)
Pulses	108.8	Stalk	2.5	272
Oil seeds	84	Stalk	2 5	210

Source District Statistical Handbook, Tawang, 2000

[3] Baruah D C, Jain AK 1998

Chapter 5

Biomass scenario in industries

5.1 Biomass generating industries

There are no large-scale biomasses generating industries in the block However, the small-scale rice/wheat mills generate some amount of biomass residue during processing of rice and wheat (Table 5 1). As the residue generated in the mills are limited and considered as a feedstock for poultry, pigs and cattle's, therefore the generated cannot be taken into account

Table 5.1 Distribution of biomass generating industries

Industry	Units	Location (no of units)	Amount of residue generated
Rice mill and wheat mill	6	Lhou (3), Jang (2), Tawang (1)	29 17 t/y

Source Primary survey 2001

5.2 Biomass generation and consumption industries

There exists only three units that consume and generate biomass in the block listed in table 5.2 As the number of units are few in number, residue generated by this units are limited and does not have any potential application

Table 5.2 Type and distribution of biomass generating and consuming industries

Industry	Units	Location (no of units)	Type and amount of residue generated
Agarbati industry	1	Tawang HQ	Bamboo scrap 1 05 t/y
Wood carving	2	Tawang HQ	Wood scrap 2 t/y

Source Primary survey 2001

5.3 Biomass consuming industries

Restaurants and hotels are the potential consumer of biomass in the block. There are also two bakery units in Tawang consuming considerable amount of biomass. These biomass-consuming units procure the biomass (mostly wood logs) from Lumla Zemithang block, which is adjacent to Tawang block. Table 5.3 exhibits the amount of biomass being consumed by the industries in the block.

Table 5.3 Types and distribution of biomass consuming industries

Industry	*Units*	*Location*	*Type and amount of biomass consumed*
Restaurant/Hotels	35	Tawang, Jang	Fuelwood 105 t/y
Bakery	2	Tawang	Fuel wood· 3 600 t/y

Source Primary survey 2001



An electric grinding mill operating in the block

Chapter 6

Biomass consumption and surplus availability

6.1 Land

6.1.1 Surplus biomass from different land categories

Table 6.1 Consumption and surplus availability of woody biomass, grass and shrubs

Type of biomass	Land type	Generation t/y	Total generation t/y	Consumption t/y		Surplus/ (deficit) t/y
				Cooking fuel	Fodder	
Woody biomass	USF	13 070 36	13 070 36	13 527 25	-	(456 89)
	Social forestry	628 25				
Grass and shrubs	Fallow land	3 16	6 12	NA	NA	-
	Waste land	2 96				
Grass	Barren land	72 24	72 24	NA	NA	-

Source *Table 4 1and Table 4 2*

Note The yield from social forestry has not been considered for calculation of surplus/deficit, as the forest dept generally permit only procurements of minor forest products from such areas in very small quantity Grass (being small in size) and shrubs are generated in very low quantity and are generation areas also sparsely located

6.1.2 Agriculture

Table 6.2 Crop residues from cultivable land

Crop type	Generation t/y	Consumption t/y			Surplus t/y
		Fodder	Cooking fuel	Mulching / organic matter	
Paddy		Nil	Nil	334 04	
Straw	334 04				
Husk	50 67				
Maize	612	Nil	Nil	612	Nil
Wheat	896 7	Nil	Nil	896 7	
Millets	224 43	Nil	Nil	224 43	
Pulses	272	Nil	Nil	272	
Oilseeds	210	Nil	Nil	210	

Source *Table 4 3 and Table 4 4*

Note. The residue production from minor crop in the district as reported (primary survey) to be finding a major utility in mulching and organic matter for enhancing the soil fertility Hence the residue production cannot supplement biomass based power generation Besides as cattle is being reared nomadic, utilisation of straw and hull is negligible and has not been taken into account

6.2 Industries

There are six biomass-generating units, comprising of rice and wheat mills There are 35 restaurants and hotels and two bakeries, which consume about 3 705 t/y of biomass.

Table 5.3 Type and distribution of biomass consuming industries

Industry	Units	Type and amount of biomass consumed
Restaurant/Hotels	35	Fuelwood 105 t/y
Bakery	2	Fuelwood· 3 600 t/y

***Source.* Primary survey 2001**

6.2.1 Surplus agro residues from biomass generating industries

Table 6.3 Surplus agro residues from biomass generating industries

Industry type	Units	Generation t/y	Utilization t/y	Surplus t/y	End use
Rice/ wheat mill	6	29 17	29 17	-	Used as feed for poultry and pigs
Total	**6**	**29 17**	**29 17**	**-**	**feed**

***Source* Table 5 1**

6.2.2 Surplus agro residues from biomass consuming & generating industries

Table 6.3 Surplus agro residues from biomass generating industries

Industry type	Units	Generation t/y	Utilisation t/y	Surplus t/y	End use
Agarbati	1	1.05	-	1 05	Currently the residues are disposed off
Wood carving	2	2	-	2	
Total	**3**	**3.05**	**-**	**3.05**	

***Source* Table 5 2**

6.3 Summary table

Table 6.4 Status on availability of biomass in Tawang

Type of biomass	Generation t/y	Consumption t/y			Surplus/(deficit) t/y
		Fodder	Cooking fuel	Mulching/matter	
Woody biomass	13 070 36	-	17 232 25	-	(4 161 89)
Grass	72 24	-	-	-	-
Shrubs and grass	6 12				
Agri residues	2 599 84	-	-	2 599 84	Nil
Industry residues	32 22	29 17	-	-	3 05

Chapter 7

Surplus biomass availability

7 1 Woody biomass

The annual sustainable yield of woody biomass from forestlands is 13 07 036 16 tonne and the sustainable yield is 13 070.36 tonnes/year (Table7.1) The use of wood biomass is mainly for the end-use of cooking and space heating The total annual consumption of firewood in the block is 17 232.25 tonnes of which, 13 527.25 tonnes is consumed in the domestic sector and 3 705 tonnes are consumed in the commercial sector. The commercial units procure the biomass (mostly wood logs) from Lumla-Zemithang block. Deficit biomass in the block is supplemented by procuring biomass from adjoining Lumla-Zemithang block The production of biomass from social forestry plantations although available, but yield from social forestry are only minor forest products and available in meagre quantity

Table 7 1 Biomass generation from Unclassed State Forest and social forestry

Land type	Area (ha)	Total growing stock (t/y)	Sustainable yield (t/y)	Consumption (t/y)	Surplus/deficit (t/y)
Unclassed State Forest	14 484	13 07 036 16	13 070 36	13 527 25	(456 89)
Social forestry	606	62 825 23	628 25	-	-

***Source** A Resource Atlas of Arunachal Pradesh 1999, Statistical Handbook of Tawang 2000*

7.2 Agriculture land

The net cropped area accounts for only 1 169 ha (5 27 %) of the block's total geographical area of 22 190 ha Wheat, paddy, maize and millet are the major agricultural crop and cover a total area of 812 ha. The total residue generation from the major crops during different periods of the year is 2117.84 tonne, of which 2067.17 tonne is straw and stalk and 50.67 tonne is rice husk (Table 7 2).

A number of field crops with lesser extent under cultivation than the above-mentioned major crops are also grown as minor crops, which are mainly pulses, oilseeds, potato and seasonal vegetables, covering an area of 680 ha. Considering pulses and oilseeds as the dominant minor crops, the total annual residue generated is 482 tonnes (Table 7 3) Residues from minor crops are consumed as fodder and organic matter, and do not have any commercial value

Table 7.2 Surplus residue generated from major crops (1999-2000)

Crop	Area (ha)	Yield t/ha	Production t/y	Residue t/y	Surplus t/y
Paddy	146	1 30	189.8	Straw 334 04 Husk: 50.67	-
Maize	165	1 85	306 0	Stalk: 612	-
Wheat	366	1 4	512.4	Stalk 896 70	-
Millets	135	0 95	128.25	Stalk. 224.43	-
Total	**812**		**1136.45**	**Straw/stalk: 2067.17** **Rice husk. 50.67**	-

***Source** District Statistical Handbook, Tawang district 2000*

Table 7.3 Surplus residue generated from minor crops (1999-2000)

Minor crops	Area ha	Yield t/ha	Production t/y	Residue t/y	Surplus t/y
Pulses	98	1 1	108 8	Stalk 272	-
Oilseeds	70	1 2	84 0	Stalk 210	-
Total	**168**		**192.8**	**Stalk: 482**	-

***Source** District Statistical Handbook, Tawang district 2000*

7.2 Industries

The industrial base in Tawang is restricted to small-scale establishments mainly comprising of six rice mills and wheat mill, and three *agarbati* and wood carving units. The total annual residue generation from such units is 32 22 tonne Almost all the residue generated in the rice mills is utilised. as feedstock for livestock. hence there is no surplus available from such units Only the residue generated from the *agarbati* and wood carving unit are available as surplus. (Table 7 4)

Table 7.4 Biomass generating industrial units in Tawang

Industry type	No units	Residue generation (t/y)	Available surplus (t/y)
Rice & wheat mills	6	29 17	Nil
Agarbati	1	1 05	1 05
Wood carving	2	2 00	2 00
Total	**9**	**32.22**	**3.05**

***Source** Primary survey 2001*

Chapter 8

Biomass collecting mechanism and management

8.1 Seasonal availability

Forest based woody biomass is the major source for energy related activity at the household and commercial (restaurant) level within the block. The current wood based biomass scenario for the block represents a glum picture (refer to table 7.1) Other than the forest based biomass, agricultural residues generated from major and minor crops constitutes about 2 599 67 t/y Based on the agricultural practice the total crop residue generated is totally utilised for mulching and as an organic matter, and feedstock for livestock Therefore no surplus amount of agricultural residue is available in the block for power generation

8.2 Sourcing mechanism

8.2.1 Agricultural residues

Based on the agricultural practice the total crop residue generated is totally utilised for mulching and as an organic matter, and feedstock for livestock Therefore no surplus amount of agricultural residue is available in the block

8.2.2 Woody biomass

Concentration of woody biomass in community forest is limited for those villages, which are away from the periphery of the block, and those divided by the river Tawang Chu. Biomass generated from homestead is mostly utilised for livestock and small replenishment for household fire. As most of the village forest in the concentrated areas being limited, household have to procure headlods or woody biomass from areas travelling a distance of 10 to 12 km with substantial time requirement for collecting. Besides a substantial amount of the biomass is being supplemented from the adjoining block (Lumla Zemithang) Woody biomass in the form of logs are being procured through truckloads and transported to the demand points.

8.3 Biomass costing

Woody biomass procured through individual collection does not per tail to cost factor, whereas those procured through trucks from the block periphery and adjoining areas require a substantial cost in terms of biomass costing ranging from Rs 2000 to 2500 and transportation being Rs 1500 to 2000 only



Collection and threshing of minor crop (Soyabean)



Crop residue used as mulch and organic matter

Chapter 9

Biomass consuming industries

Biomass consuming industries

Biomass based industrial activity in Tawang block is extremely poor Other than the 6 wheat and rice mills ,one *agarbati* and two woodcarving units that operate within the block, there is no other industrial unit. Table 9 1 presents the distribution of industries in the block.

Table 9.1 Distribution of industries in Tawang

Industry	No of units	Location
Rice/ wheat mills	6	Lhou -3,Jhang -2,Tawang -1
Agarbati	1	Tawang
Wood carving	2	Tawang

***Source** Primary survey 2001*

Even though biomass consuming industries are limited in the block, other establishments that consume an appreciable amount of biomass are the restaurants located mostly in the district headquarter. About 35 small hotels and restaurants are found in the Tawang block headquarters, where the annual firewood consumption on an average for each unit is about 105 tonnes. Besides, mostly these units use LPG and kerosene as fuel for cooking applications

As burning of firewood in the restaurants is carried out in earthen cook stoves, the use of improved cookstoves in such establishments would help in reduction of the firewood consumption by about 20-30% resulting in firewood saving annually. However, field trials on energy savings from improved cookstoves at individual level are yet to be undertaken in the block Thus energy savings cannot be computed based on assumptions.

Chapter 10

Power generation potential, location and economics

The current power consumption per month in the block (September 2001) is 120 42 MWh/monthly, of which domestic consumption is 117 24 MWh/month amounting to 97 35%. There is an additional demand estimated only for the remaining unelectrified villages (10 number) amounting to 2 50 MWh/month. The total monthly generation for the block 3370 57 MWh/month from Kitpi Hydel and the DG sets at Tawang Out of the total generation only 505 58 MWh/month (15%) is being utilised as per information from Electrical Subdivision, Tawang under the present T & D facilities

10.1 Power generation potential

Given the biomass resources assessed and their utilization in the study block, woody biomass and agricultural residues do not support biomass based power generation units This is based on inferences drawn from informations obtained during primary survey and later corroborated through analysis of secondary informations rendering to a deficit of 4161.89 t/y woody biomass and no surplus agricultural biomass As referred in chapter 7 relating to agricultural land availability, only 5.27 % area of total geographical area of the block is under cultivation. Moreover the topographic feature of the block has restricted the extension of area under cultivation and crop intensification. Besides surplus agricultural biomass that can support biomass based power generation in near future is totally ruled out. Hence, the present assessment study does not yield an over all feasibility for biomass based power generation

10.2 Location of biomass based power generating units

The present village electrification scenario represent 89 58 % where the remaining 10.41 % remains unelectrified and is located towards south east part of the block. Interactions with officials from Power Department have revealed that the department has proposed electrification of the 10 unelectrified villages. However, based on resource availability, unelectrified condition and number of household per village only a few unelectrified villages namely Brakar Gompa, Tseratse, Langteng, Collengteng can be considered for off grid decentralized power generation based on biomass gasifier and 100 % producer gas engine Another option for introduction of biomass based power generation through gasifier is possible at district headquarter, Tawang, where three diesel power generating units of capacities 625 kVA, 500 kVA and 300 kVA are in operation However, suggestion for fuel wood supplement for 100 % biomass gasifier

based decentralized power generation system has to be a centralized procurement mechanism

Biomass gasifier based system with 100% producer gas engine as the prime mover
The proposed system is shown in figure.1 consisting of the gasifier, gas-cleaning train, buffer gas storage and a 100% producer gas engine. Either fuelwood grown on plantation or briquettes produced from agro residues can be used in the gasifier. Addition of a briquetting machine provides an opportunity for income generation through sale of briquettes, and also solves the problem of load factor in remote areas. The buffer storage and the diesel generation modified to run only on producer gas are shown in figure 2 & 3 respectively.

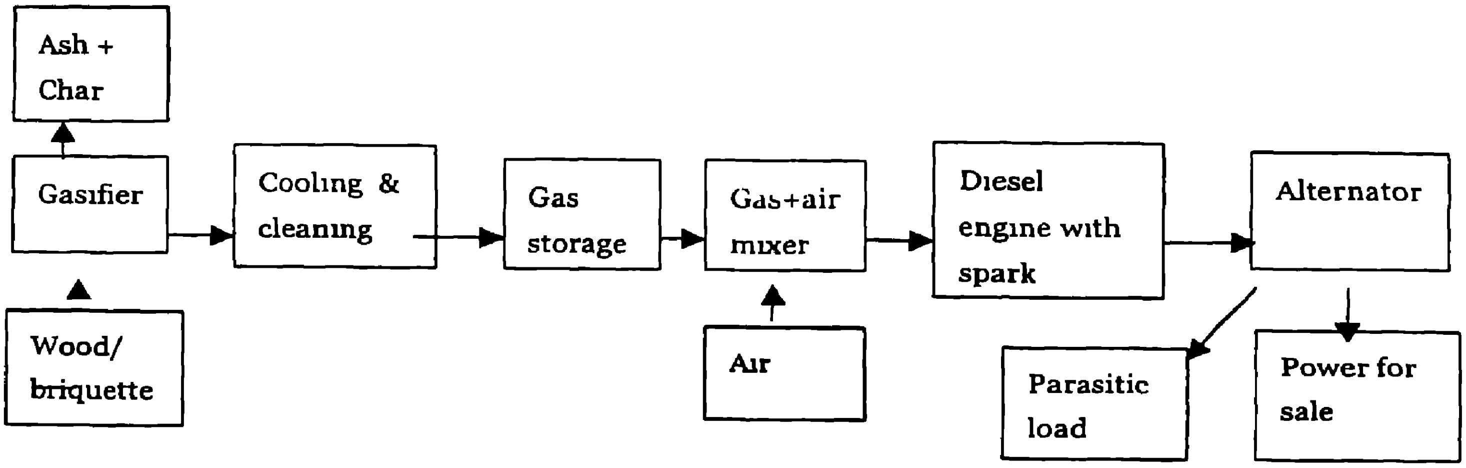


Figure 1: 100% biomass gasifier based decentralized power generation system

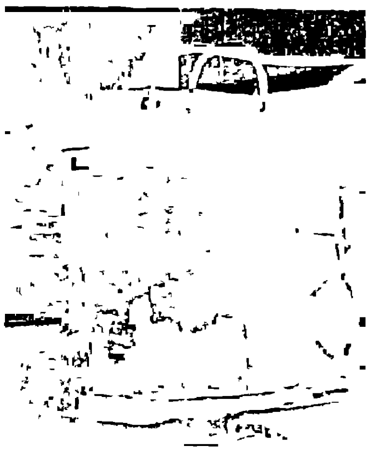


Figure 2 Gas storage system.



Figure 3 View of the modified diesel generator.

10.3 Economics

The cost of generation per kilowatt of power would depend on the capacity of the system and its application MNES provides a capital subsidy of 90% for gasifier based systems in the Northeastern region irrespective of the capacity Therefore under the present circumstances, subsidy can be availed of for any capacity Financing can also be availed of, from IREDA at low interest rate, which for NE region is only 2.5 % Table 10. 4 provides an approximate cost estimation for biomass based power generation under desired capacities.

Table 10. 4 Cost estimation for off grid, decentralized biomass based power generation

Sl No	A. Capital costs		Proposed capacities	
			5 kW	**10 kW**
1	Gasification unit, cooling cleaning system and instrumentation @ Rs 7500 per kW		37 500 00	75 000 00
2	Generating set @ Rs 4 000 – 5 000 per kW		25 000 00	50 000 00
3	Erection & commissioning (approx 15%-20 % of capital cost of gasifier and generator)		12 500 00	25 000 00
4	Cost of civil works (foundation, engine room, water supply, drainage, etc) @ Rs 2000 per kW but the cost would be about 50 % more for system less than 100 kW capacities		15 000 00	30 000 00
5	**Total**		**90 000.00**	**1 80 000.00**
6.	**B. Operational expenditure per month (for running 6 hours daily)**			
7	Fuel	Diesel @ Rs17 00 per litre	1 530 00	3 060 00
		Biomass @ Rs 1 000 00/ tonne*	900 00	1 800 00
8		Cost for transportation of biomass	-	-
9	Labour	Skilled worker (1) @ Rs 3000/month	3 000 00	3000 00
		Semi skilled worker (1) @ Rs 2 000 / month	2 000 00	2000 00
10	Cost of lubrication @ Rs 250 per month		2 50 00	2 50 00
11	**Total**		**7 680.00**	**10 110.00**

Note The above estimates do not include transmission and distribution cost as the length of distribution would be variable The costs are indicative and are based on the survey of the current market prices, which are liable to change

Unelectrified Villages in Tawang Block:

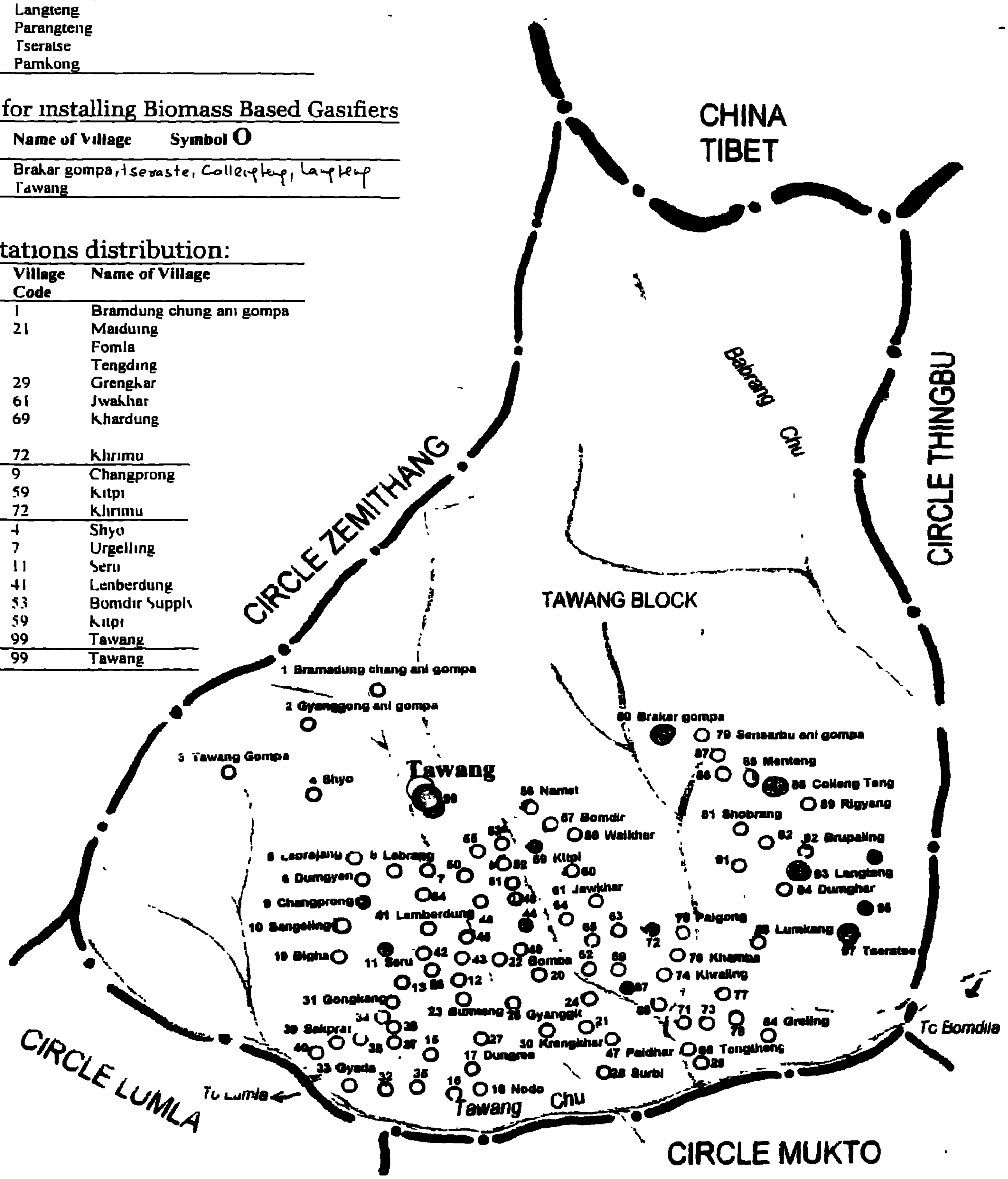
Village Code	Name of Village	Symbol ◉
13	Kangteng	
44	Sikharteng	
67	Shorra	
70	Bongbong	
80	Brakar gompa	
88	Collengteng	
93	Langteng	
95	Parangteng	
97	Tseratse	
98	Pamkong	

Location for installing Biomass Based Gasifiers

Village Code	Name of Village	Symbol O
80	Brakar gompa, Tseraste, Collengteng, Langteng	
99	Tawang	

EB Substations distribution:

Substation Capacity	Village Code	Name of Village
	1	Bramdung chung ani gompa
25 kW	21	Maiduing
		Fomla
Symbol O		Tengding
	29	Grengkar
	61	Jwakhar
	69	Khardung
	72	Khrimu
	9	Changprong
63 kW ●	59	Kitpi
	72	Khrimu
	4	Shyo
	7	Urgelling
100 kW	11	Seru
	41	Lenberdung
Symbol O	53	Bomdir Supply
	59	Kitpi
	99	Tawang
500 kW ●	99	Tawang



Distribution of unelecrified village, proposed generation centers and EB substation in Tawang block

Chapter 11
Recommendations and proposals

The biomass resources available in Tawang block are in the form of wood and agriculture residue The current uses of these resources are wood for cooking; residues for mulching and manure, fuel and fodder, respectively The current energy consumption scenario revealed that domestic sector is the major consumer, followed by commercial sector (restaurants) Industrial power demand is insignificant in the absence of any large-scale industries except for small-scale units like rice/wheat mills.

The consumption pattern of woody biomass in the block, with the consumption exceeding the sustainable yield, leaves no scope for surplus woody biomass The concentration of households in the unelectrified villages being limited and biomass for power generation being deficient in the block, *hence centralized generation of power is economically not a feasible proposition* In the present scenario of power generation based on micro hydro and DG sets at Tawang, available power to mitigate the additional demand 2 50 MWh/month exist based on the present 15% evacuating capacity through grid extension But off grid **decentralized power generation based on biomass gasifier and 100 % producer gas engine is a feasible alternative** for electrification of identified villages. The power generated could thus electrify the village Thus, the following options are recommended for dissemination of gasifiers for power generation at decentralized level

- Based on cost economics of grid extension and decentralized power generation based on biomass gasifier, economically feasible option can be taken into consideration for village level electrification
- Gasifier capacities of **5kW and 10kW** can be installed at the villages
- The dissemination of gasifier technology can be demonstrated on a pilot scale
- Since the quantity of biomass to be used for generating power through 5 kW and 10 kW is marginally low amounting to 30 kg and 60 kg per day respectively, the required amount can be collected by the village beneficiaries on day to day basis
- Potential for introduction of biomass based power generation through gasifier is possible at district headquarter, Tawang, where three diesel power generating unit of capacities 625 kVA, 500 kVA and 300 kVA are in operation. However, suggestion for fuel wood supplement for 100 % biomass gasifier based decentralized power generation system has to be a centralized procurement mechanism. The substitution of the diesel generator through biomass based gasifier unit would lead to an annual substantial cost savings which is presented below

Table: Comparative economic analysis

Capacities of DG sets in Tawang	Fuel/hr			
	Diesel		Wood	
	Litres /hr	Cost (Rs.)	Kg*	Cost (Rs.)
625 kVA	125	2125.00	625	625.00
500 kVA	85	1445.00	500	500.00
300 kVA	30	510.00	300	300.00

Source: DOP, Tawang

**Note Fuelwood required @1kg/kWh*

Under the above comparative circumstances the annual cost of diesel for 625 kVA DG set is Rs. 7 65 000.00 and for that of wood fuel for gasifier is Rs. 4 50 000.00(including 100 % transportation cost). Hence, this, comparative analysis shows an annual savings of Rs. 3 15 000.00. Therefore, introduction of biomass based gasifier for power generation seems to be an effective cost savings options.

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